APPLE ESSENCE RECOVERY COSTS

Cost analysis for the Department of Agriculture's process shows $12,000 in equipment necessary to ready plant . . . .

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A PROCESS for recovering the aroma of apple juice in concentrated or essence form was developed in 1944 by the Eastern Regional Research Laboratory.[1] Since that time, publications have been issued by the Laboratory reporting the application of this process to the juice of other fruits and to the preparation of full-flavor concentrated fruit juices.[2, 3, 4, 5, 6] When cost estimates were made on processes entailing essence recovery, they covered juice-processing operations as well as essence recovery itself.[4, 5, 6] This paper deals with the cost of producing apple essence as a separate operation—essence intended for sale rather than for restoration to the juice from which it was derived. The principles on which essence recovery is based and a discussion of equipment design have been published.[7]

Most manufacturers of essences have been making them for restoration to their own products. There is now, however, a rapidly increasing demand for essence, for use in contributing true fruit flavor to jelly, candy, carbonated beverages, ice cream, vinegar concentrate and other food products. Obviously this demand can be met only by the producer who doesn't need the essence in his own product. In the case of apple essence this could be the manufacturer of cider vinegar, bland apple sirup, or concentrated apple juice for the jelly trade.

Essence from Peels and Cores

Apple cider vinegar is frequently made from low-grade cull apples, the juice of which would be unsuitable as a source of essence, not only because the resulting essence would not have the aroma of fresh apples but because it would also probably be too high in ethyl alcohol.[8] Peels and cores obtained, for example, in the manufacture of apple slices or applesauce, are frequently used as a source of juice that is converted to vinegar, made into bland sirup, or into concentrate for manufacture of jelly. Good apple essence can be made from juice obtained from peels and cores if they are processed into juice before fermentation takes place and if seed breakage is minimized Some peeling machines have small-diameter coring tubes, which leave most of the seed adhering to the apple slices, from which they are later washed and eliminated by screening. Peels and cores from such machines should yield juice well suited to essence recovery. When cores remain virtually intact through the peeling and coring operations, care must be taken in grinding. The breakage of seeds which pass to the hammer mill can be minimized by operating the mill at the slowest practical speed and by using the largest holes in the screen consistent with good recovery of juice. Blunt rather than sharp head hammers in the mill may also reduce seed breakage. Broken seeds contribute a benzaldehyde-like character to the essence, which in a moderate degree may be desirable for certain uses. When too many seeds are broken, however, it becomes unpleasantly strong and the essence may actually become oily. If this occurs, chilling the essence and decanting the oily layer that forms on top will leave an aqueous essence which may be acceptable for some uses.

Until recently most apple essence was made between 100-fold and 150-fold. At present there is a demand for higher fold essence. The apparatus required for recovery of essence between 100-fold and about 200-fold is shown diagrammatically in Fig. 1. The equipment items appear in Table I with an estimate of their cost. Freshly pressed juice in tank (1) is delivered at a constant rate by pump (2) through preheater (3) and vaporizer (4). In the preheater the juice is brought to its boiling point, at which temperature it enters the vaporizer, where enough steam is used in the jacket to vaporize 10 per cent of the juice. This is sufficient to release all the aroma from apple juice. The vapors are separated from the stripped juice in the separator (5), and the stripped juice is either flashed into the vacuum evaporator, if concentrate or sirup is to be made from it, or it is cooled in (6) to about 85 deg. F. for fermentation to vinegar. The aroma-containing vapors are concentrated in packed column (7) to the desired fold by regulating the drawoff of essence by pump (10) with respect to the rate of juice fed by pump (2). A reboiler at the bottom

TABLE I—SUMMARY OF EQUIPMENT

Item No.		Cost
1	Holding tank. Stainless steel, closed, 4-ft. diameter by 5½ ft. deep; 500 gal.	$ 1,500
2	Pump. Sanitary type, positive delivery. 1000 gal./hr.	700
3	Preheater. Stainless steel tubes, carbon steel shell, 20 sq. ft.; heats 1000 gal./hr. from 70 deg. to 210 deg. F.	2,700
4	Vaporizer. Stainless steel tubes, carbon steel shell; vaporizes 10 per cent of feed juice	2,800
5	Separator. Stainless steel, 11 in. diameter by 34 in. high	500
6	Cooler. Stainless steel tubes, carbon steel shell, 110 sq. ft.; cools 900 gal. per hr. from 210 deg. to 85 deg. F.	1,400
7	Fractionating tower. 11 in. diameter by 13 ft. high, stainless steel, 1½-in. Raschig rings; 10 ft. enriching section; 2 ft. stripping section; 1 ft. spacing	1,700
8	Condenser. Stainless steel tubes, carbon steel shell, 15 sq. ft.; condenses 833 lb./hr. of vapor and cools to 190 deg. F.	350
9	Liquid-vapor separator (price included in Item 8).	
10	Positive delivery essence pump, sanitary type; handles 55.6 lb./hr.	100
11	Essence chiller, stainless steel, 2.4 sq. ft.; cools 55.6 lb. of essence per hour from 190 deg. to 38 deg. F. Cost of chiller, $100. Refrigeration unit for chiller, $300	400
12	Vent gas scrubber. 2 in. diameter by 18 in. high. Packing, ¼ in. saddles	50
		$12,200

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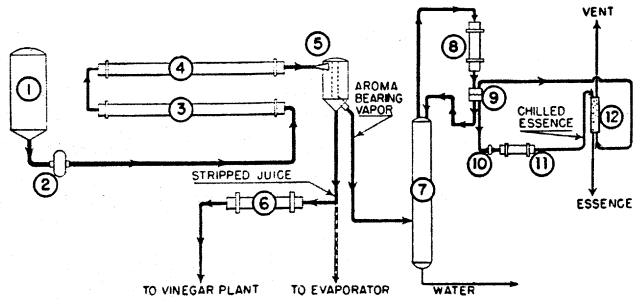
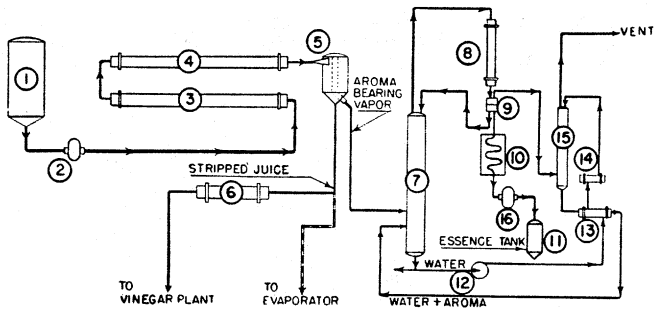


• *Fig. 1. Diagram of apparatus for producing apple essence of less than 250-Fold. (See text for description of process.)*



• *Fig. 2. Diagram of apparatus for producing apple essence of more than 250-Fold. (See text for description of process.)*

of the column supplies the heat necessary to offset radiation and to reheat the reflux from 190 deg. F. to its boiling point. The vapors from the fractionating column are condensed in (8), where their temperature is further reduced to 190 deg. F. There is an opportunity here to utilize some of the heat in the vapors from (7) to partially preheat the cold juice before it goes to (3). Against the consequent saving in steam must be offset the cost of a heat exchanger having small diameter tubes to reduce fouling and a stainless steel shell to avoid contamination of the aroma-bearing vapors. There would also be the additional cost of an after condenser for the vapors not condensed by the heat exchanger. Reflux splitter (9) returns as reflux to column (7) that portion of the essence not drawn off by pump (10). Pump (10) delivers essence at 190 deg. F. to chiller (11), where its temperature is reduced to 38 deg. F. This cold essence is then used to scrub the vent gas, which leaves splitter (9) at 190 deg. F. Scrubbing is done in a small packed tube (12), from which the cooled scrubbed gases leave at about 47 deg. F. If the scrubber is well insulated, essence should emerge at below 50 deg. F. The liquid discharged from the bottom of the fractionating column is in effect distilled water. It might well be returned to the stripped juice if the juice is to be made into vinegar. If this is done, the reduction in yield of vinegar caused by recovering 150-fold essence would be only 0.67 per cent. In making 500-fold essence, the reduction in vinegar yield would be only 0.20 per cent. Obviously if a concentrate is made from the juice after the aroma is stripped off there would be no reduction in yield of concentrate as a consequence of essence recovery.

Various arrangements of essence-recovery equipment have been described in the publications of this Laboratory.[1, 2, 3, 4, 5, 6, 7, 9] The arrangement shown in Fig. 1 represents a practical compromise between simplicity and versatility. Although designed for recovery of essence from apple juice, it would be equally well suited to Concord grape juice. In the latter case, the capacity would be only one-third that of apple juice, since 30 per cent vaporization instead of 10 per cent is required for release of the aroma. Although the apparatus is somewhat more elaborate than necessary for recovering essence from the distillates obtained during preserve manufacture,[9] it would adequately perform this function.

Fig. 2 shows the arrangement of apparatus for making essences of higher fold. The difference between the apparatus used for low- and high-fold essences lies entirely in the treatment of the vent gas from the essence condenser. In the former (Fig. 1), the vent gas is scrubbed with chilled essence before discharging at about 47 deg. F. At this temperature the loss of aroma in the vent gas is so small as to be negligible if the essence fold is below about 200. As the fold of the essence is increased, however, vent gas losses increase because the gas leaves the system in equilibrium with increasingly concentrated essence. Thus, if high-fold essences are to be produced without significant loss in the vent gas, a different arrangement must be used. As shown in Fig. 2, the vent gas is scrubbed with water at 100 deg. F. instead of chilled essence. Column bottoms are used for this scrubbing, as they constitute an autogenous source of odorless water.

In Fig. 2 items 1 through 9 are the same as in Fig. 1. Item 10 is an essence cooling coil and item 16 is a positive delivery pump which delivers essences to tank (11). A pump (12) circulates column bottoms from 7 through heat exchanger (13) and cooler (14) to scrubber (15). Some aroma-containing water from 15 is returned to fractioning column (7). Items 10-16 are all quite small; total cost is under $500.

Because of the presence of pectin and other substances, apple juice tends to foul hot metal surfaces. This tendency may be worse in juice from peels and cores. Fouling becomes apparent by the increased steam pressure required to maintain the desired temperature in preheater (3). Fouling in the evaporator (4) should be negligible if the juice is maintained at or slightly above its boiling point as it emerges from the preheater. In designing the preheater, the number and inside diameter of the tubes should be chosen to obtain a velocity of at least 20 ft. per second and to assure turbulent flow of fluid to minimize fouling. Deposits, which may foul the preheater tube, can be quickly and easily eliminated by the following procedure: Momentarily replace the juice feed by

TABLE II—CAPITAL COSTS

	150-Fold Essence
Equipment	$12,200
Erection of Equipment	3,100
Instrumentation	500
Piping and Ductwork	2,500
Erection of Piping and Ductwork	1,700
Heating — Installed	300
Lighting — Installed	300
Power — Installed	100
Freight on Equipment	200
Contingencies	2,000
Engineering Fees	2,500
Total fixed capital	$25,400
Working capital	7,300
Total capital	$32,700

water feed, cut the steam pressure to about 15 p.s.i.g., and then shut off the water feed. The steam then formed in the preheater tubes strips off the deposit, which passes into the stripped juice and is automatically eliminated in subsequent processing. This requires about 1 minute.

Preheater fouling can be prevented by steam injection heating.[10] This requires a dependable source of odorless steam, however, and entails the evaporation of the additional water from the injected steam, which may amount to as much as 15 per cent of the weight of the juice. The two methods will yield essence of equal quality.

In estimating the cost of producing apple essence, it is assumed that this enterprise will be adjunct to a plant producing apple juice products that do not require the restoration of essence, for example, vinegar, bland apple sirup or ordinary apple concentrate from either sound apples or peels and cores. The cost of the juice is properly borne by the juice products, and hence does not appear as a charge against essence. It is further assumed that the existing property affords rail and road facilities, that enclosed floor space is available for the essence-recovery equipment, and that office and facilities are adequate for the new enterprise. The operating season is assumed to be 55 working days at 16 hours a day during the rush season of about 10 weeks, and 33 working days at eight hours a day through the approximately six weeks remaining. The services of one man for eight hours a day are provided for cleaning up at the end of the day.

The capacity of the essence-recovery unit is taken as 1000 gal. per hr. of juice, which amounts to 6.67 gal. per hr. of 150-fold essence or 2 gal. per hr. of 500-fold essence. The capital costs for the new enterprise are shown in Table II. They amount to a little more than $25,000 of fixed capital with a working capital of approximately $7,000 when 150-fold essence is produced. The figures for 500-fold essence would be substantially the same. Table III, a cost sheet, shows that the estimated cost to make one gal. of 150-fold essence is $2.16, and one gal. of 500-fold, $6.76. These figures include not only the cost of materials, labor, and factory overhead but interest on working capital, administration, and general expense.

From these data, it is apparent that apple essence can be recovered from the processing of peels and cores with moderate capital outlay. At the current market price for essence, there will be an adequate return on the investment after payment of selling costs and income tax.

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TABLE III—COST SHEET

	150-Fold Cost per yr.	500-Fold Cost per yr.
Prime Cost		
Material	Nil	Nil
Labor		
1 operator at $1.50/hr. per shift; 1 helper at $1.00/hr. per shift		
1 cleaner at $1.00/hr., 8 hr./day		
1144 man hours at $1.50/hr. $1,716.00		
1848 man hours at $1.00/hr. 1,848.00	$3,564.00	$3,564.00
Total Prime Cost	$3,564.00	$3,564.00
Indirect Materials		
Ice		
7200 lb. at $0.25/100 lb.	18.00	
3600 lb. at $0.25/100 lb.		9.00
Cans. 1 gal. lacquered		
7630 cans at $0.22 ea.	$1,678.00	
2286 cans at $0.22 ea.		503.00
Total Indirect Materials	$1,696.00	512.00
Factory Overhead		
Indirect Labor		
Supervision: 5% of salary	375.00	375.00
Watchmen: 5% of company cost	150.00	150.00
Office Help: 10% one girl's time at $35/wk.	182.00	182.00
Truck Operator: 5% of salary	45.00	45.00
Total Indirect Labor	752.00	752.00
Indirect Expense		
Fixed		
Insurance, Public Liability and Fire: 1% of Fixed Capital	254.00	260.00
Taxes: 2% of Fixed Capital	508.00	519.00
Interest: 5% of Fixed Capital	1,269.00	1,298.00
Depreciation: 10% of Fixed Capital	2,539.00	2,597.00
Total Fixed Indirect Expense	$4,570.00	$4,674.00
Non-Wage Payments		
Social Security: at current rate	69.00	69.00
Workmen's Compensation. at current rate	50.00	50.00
Unemployment Insurance: at current rate	244.00	244.00
Total Non-Wage Payments	$ 363.00	$ 363.00
Utilities:		
Power		
2133 KWH at $0.015/KWH	32.00	
3000 KWH at $0.015/KWH		45.00
Steam: 2,666,200 lb. at $0.65/1000 lb.	1,733.00	1,733.00
Water:		
14,970,000 gal. at $0.03/1000 gal.	449.00	
15,030,000 gal. at $0.03/1000 gal.		451.00
Total Utilities	$2,214.00	$2,229.00
Miscellaneous		
Maintenance, Repair and Renewals: 6% of Fixed Capital	$ 1,523.00	$ 1,558.00
Gasoline	54.00	54.00
Factory Supplies	230.00	235.00
Rent: 6% on investment in occupied space plus 3% maintenance on same	286.00	286.00
Total Miscellaneous	$ 2,093.00	$ 2,133.00
Total Indirect Expense	9,240.00	9,399.00
TOTAL FACTORY OVERHEAD	$ 9,992.00	$10,151.00
FACTORY COSTS	$15,252.00	$14,227.00
INTEREST ON WORKING CAPITAL	100.00	94.00
TECHNICAL SERVICES	300.00	291.00
ADMINISTRATIVE AND GENERAL EXPENSE	854.00	860.00
COST TO MAKE	$16,506.00	$15,472.00
COST TO MAKE (per gal.)	$ 2.16	$ 6.76

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